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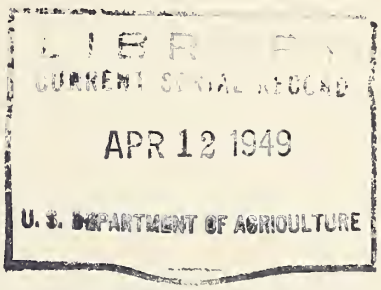

PORTABLE WATER-JET PUMPS

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Mechanical oil pumps as a source of low pressure in the vacuum distillation of high boiling acid chlorides are unsatisfactory, since continued use of an oil pump for this purpose usually results in corrosion and pump failure, in spite of protective traps and frequent oil changes. Use of a water aspirator connected to a water line, although it avoids the corrosion problem encountered with mechanical pumps, introduces the following problems: fluctuation in line water pressure, low line water pressure, warm water in line (especially in summer), inconvenient water outlets and drains, and, in many localities, the relatively high cost of water.

These problems were overcome here by circulating cooled water at virtually constant pressure through a water jet. The assembly is mounted so that it can be easily moved to any part of the laboratory. Readily available parts may be used in its construction. This equipment, suitable for distilling high boiling acid chlorides in the pressure range of 5 to 10 mm. Hg., has proved generally useful and satisfactory here for 18 months, and replicas have been constructed and used advantageously by others. The present paper, prepared largely in response to requests for a detailed description of the water-jet pumps, describes the construction and performance of two portable pumps of different size and capacity.

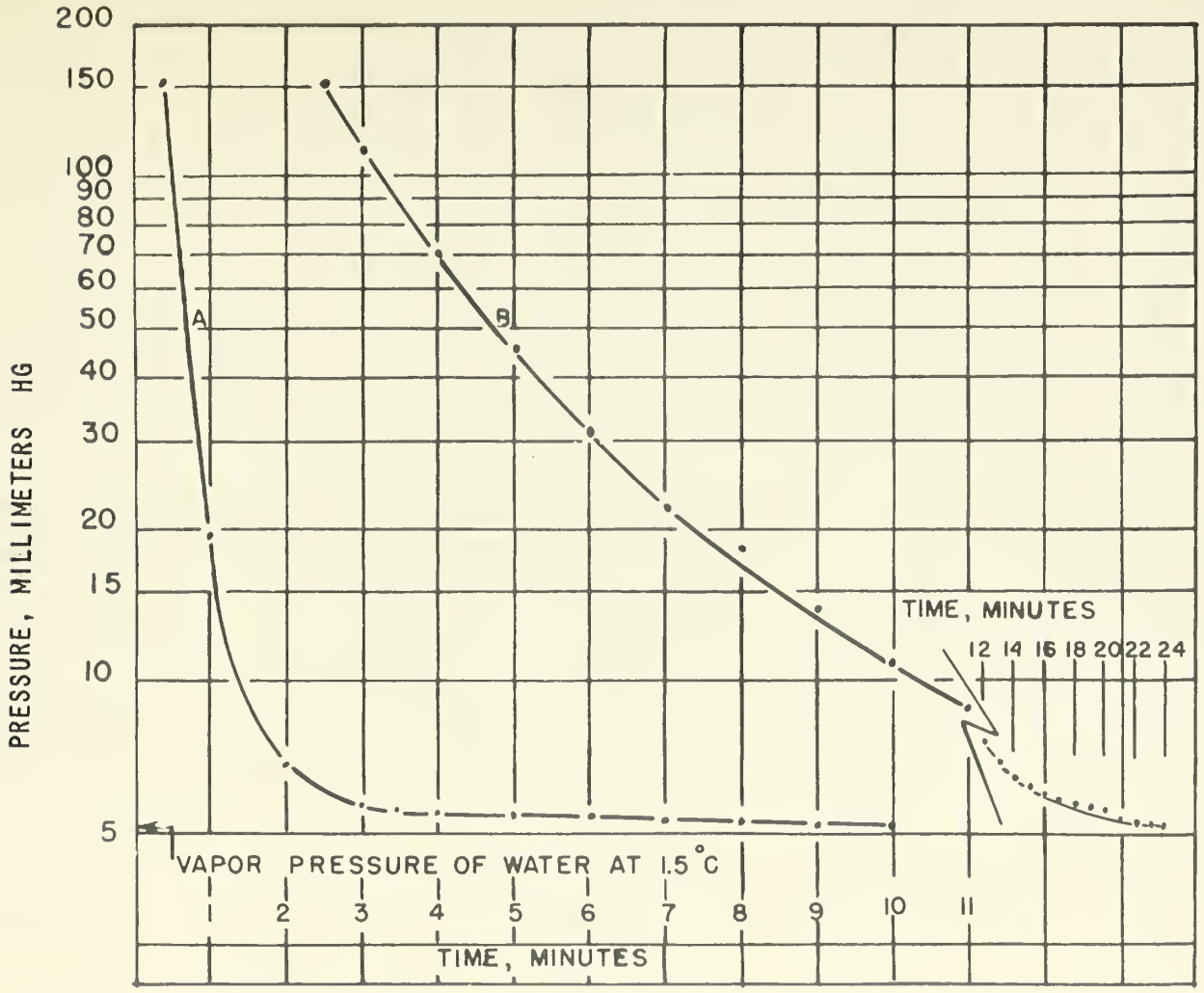
The technical literature contains articles (1, 2, 3) on equipment similar to the larger apparatus described in this paper. No reference has been found, however, to equipment similar to the smaller assembly, which is very convenient for use in limited space. A commercial unit (Whittington Pump and Engineering Company, "Handivac")[A] is available for use at pressures as low as 50 mm. Hg. In general, the apparatus outlined herein combines most of the advantages of those reported earlier.

Figure I shows the pumping rate of these two pumps when evacuating a closed system slightly larger than 5 liters. These curves show that a 5-liter closed system can be evacuated to a pressure of 5.2 mm., approximately the vapor pressure of the circulating water, in 4 minutes with the large equipment, and in 22 minutes with the smaller assembly. A duplicate of the large apparatus yielded the following data (4) on pumping rates:

(1) with Shutte-Koerting 00 ejector: 1.05 cu. ft. free air/min.

(2) with Fisher ejector: 0.2 cu. ft. free air/min.

[A] THE MENTION OF SPECIFIC BRANDS OR MANUFACTURERS SHOULD NOT BE CONSIDERED AN ENDORSEMENT OR RECOMMENDATION OF THESE OVER OTHERS NOT MENTIONED.



PUMPING RATE - 5 LITER CLOSED SYSTEM
(WATER AT 1.5°C)

A - LARGE EQUIPMENT
B - SMALL EQUIPMENT

FIG.1

These data indicate that the large equipment (using the OO ejector) has a pumping speed for free air equal to the Cenco Pressovac or Welch Duo Seal 1406 mechanical oil pump (5).

DESCRIPTION AND OPERATION OF LARGE PUMP

Figures 2 and 3 give details of construction and assembly. The pump, motor[B] and bypass were purchased as a unit, completely assembled and mounted on 10 inch channel iron. The remaining operations, that is, construction of the frame and insulation box and assembly of the various parts, were carried out in this Laboratory.

The operation of this equipment is straightforward and requires few precautions. The crock used as water reservoir should contain at least 5 gallons of water. If desired, a little ethanolamine may be added to the water to neutralize acid vapors trapped during the distillation of corrosive materials such as acid chlorides. When pressures of 6 to 10 mm. are required, the crock should be packed with large pieces of ice to keep the temperature of the water low. The ice should be rinsed clean before use. The screen at the bottom of the intake line will collect most of the larger particles of foreign matter that would clog the ejector. The intake line is easily removed with a pipe wrench for the purpose of cleaning or replacing the strainer. A gradual drop in water pressure during normal operating conditions usually indicates that the strainer requires cleaning. Water pressure can be controlled by the bypass, the pressure dropping gradually as the bypass is opened. In this laboratory, the pump is usually operated with the bypass closed, thus utilizing the maximum water pressure at the top of the ejector.

This pump requires priming to start unless a foot valve is installed (4) on the intake line. For our purpose--the distillation of corrosive materials--it is desirable that the pump, ejector, and lines be drained and washed with water after each run, and therefore the pump is primed each time it is used. This is done by removing the 1-1/4 inch plug (Fig. 3) and pouring about a quart of water in the top. The plug is immediately replaced and given a few turns, and the motor is started. The pump priming will be completed while the plug is being tightened with a wrench. This operation may require a little practice at first. The water will circulate at a pressure of about 55 lbs. per square inch if the various fittings are tight and the strainer is clean. *All valves should be closed before the pump is started.*

[B] SAFETY PRECAUTION. IF A 1-H.P. 220-V., 3-PHASE MOTOR IS USED AS SHOWN IN FIG. 3, AN ELECTRICAL CONNECTION ON THE CORD SIMILAR TO THE EVER-LOK NO. 8004, 4-POLE RECEPTACLE AND PLUG (RUSSELL AND STOLL CO., NEW YORK) SHOULD BE USED.

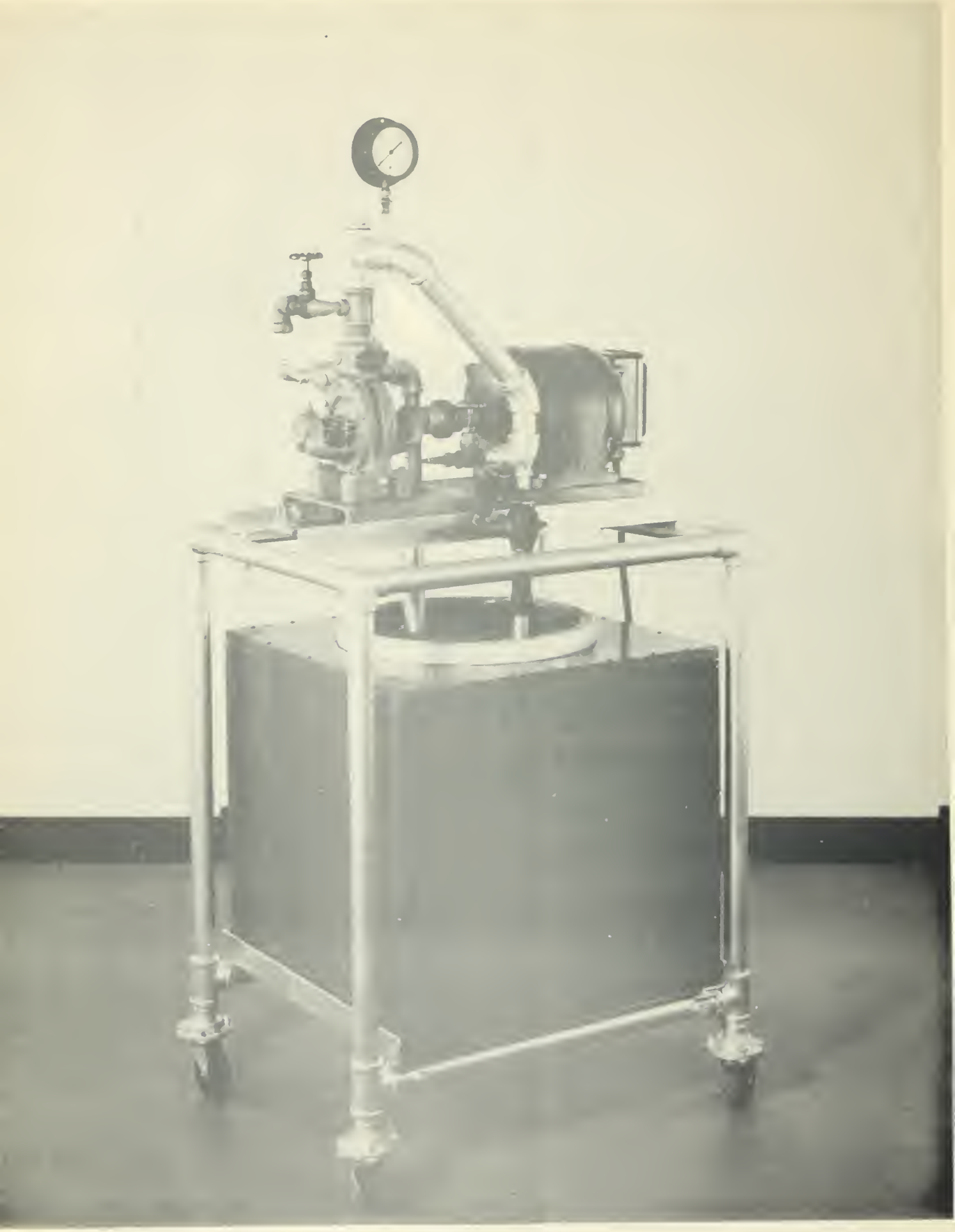


FIG. 2

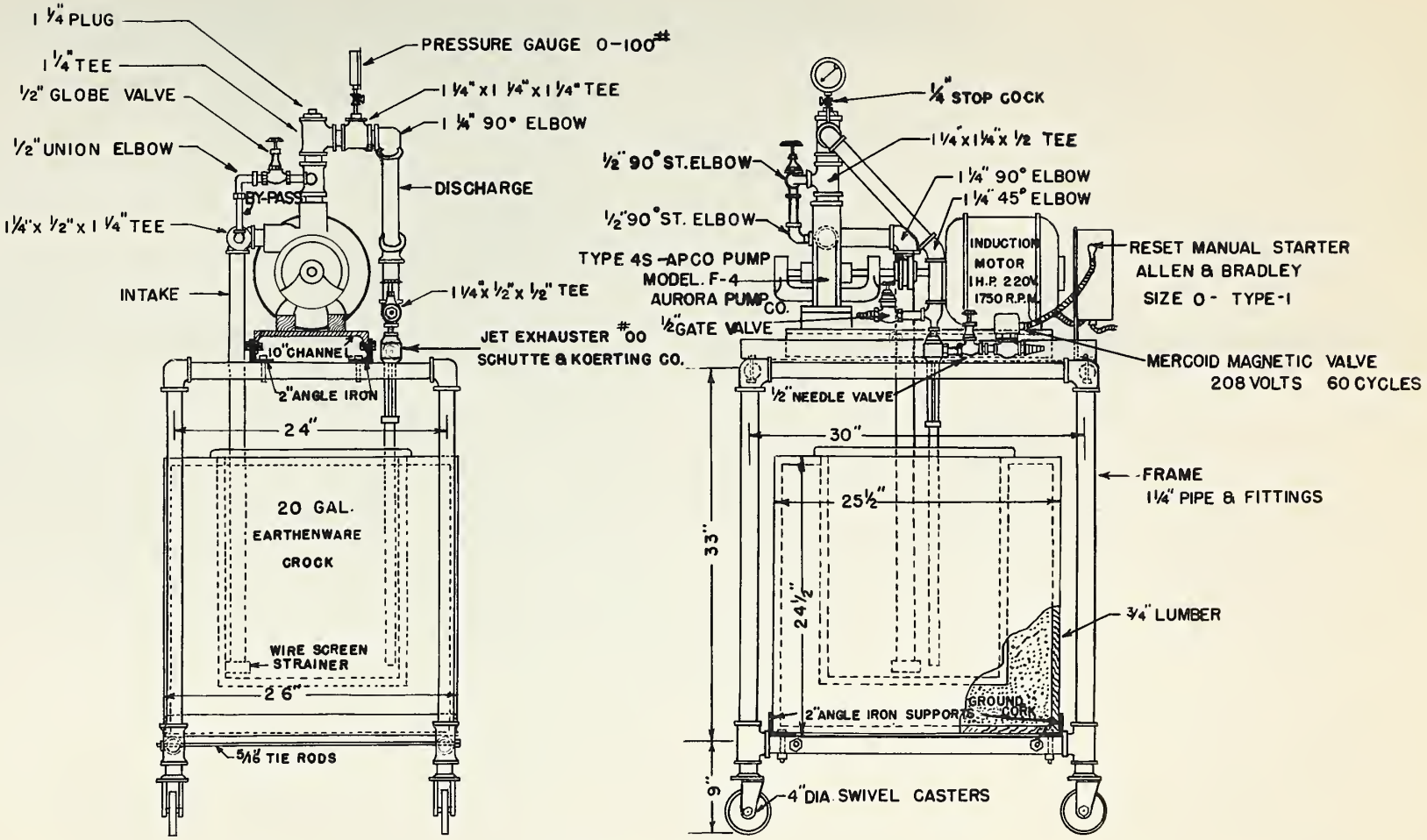

1 ¼" PLUG
1 ¼" TEE
½" GLOBE VALVE
½" UNION ELBOW
1¼" x ½" x 1 ¼" TEE
INTAKE
PRESSURE GAUGE 0-100#
1 ¼" x 1 ¼" x 1 ¼" TEE
1 ¼" 90° ELBOW
DISCHARGE
BY-PASS
1 ¼" x ½" x ½" TEE
JET EXHAUSTER #00
SCHUTTE & KOERTING CO.
10" CHANNEL
2" ANGLE IRON
24"
20 GAL.
EARTHENWARE
CROCK
WIRE SCREEN
STRAINER
26"
5/16" TIE RODS
¼" STOP COCK
1 ¼" x 1 ¼" x ½ TEE
½" 90° ST. ELBOW
1 ¼" 90° ELBOW
1 ¼" 45° ELBOW
½" 90° ST. ELBOW
TYPE 4S-APCO PUMP
MODEL. F-4
AURORA PUMP CO.
INDUCTION
MOTOR
1 H.P. 220V
1750 R.P.M.
RESET MANUAL STARTER
ALLEN & BRADLEY
SIZE 0 - TYPE-1
½" GATE VALVE
MERCOID MAGNETIC VALVE
208 VOLTS 60 CYCLES
½" NEEDLE VALVE
30"
FRAME
1¼" PIPE & FITTINGS
25½"
33"
24½"
¾" LUMBER
GROUND
CORK
2" ANGLE IRON SUPPORTS
9"
4" DIA. SWIVEL CASTERS

FIG. 3

The vacuum line leading from the side arm of the ejector consists of a one half inch needle valve and a solenoid valve, connected in parallel (electrically) with the motor and the necessary fittings. When the needle valve is opened, the system attached to the serrated tip is evacuated. The solenoid valve protects the evacuated system from water back-up due to current failure. It should also be protected as well as possible from water back-up due to a clogged line or ejector. This is best done by using a trap and check valve between the needle valve and the evacuated system. There are many references in the literature to various types of check valves. Many will retard the back-up of water sufficiently for the operator to close the needle valve before damage is done.

Operation of the large pump is terminated, and the pump is cleaned as follows: The needle valve is closed, and a piece of rubber tubing long enough to reach a drain is attached to the serrated tip of the gate valve. The bypass is opened until the water pressure is reduced to about 10 lbs., and then the gate valve is opened. The pump will empty the crock to the level of the intake line in several minutes. The motor is stopped when no more water comes out of the gate valve, and then *this valve is closed.* Fresh water is poured into the opening at the top (the same one used for priming the pump) to wash out the pump directly below and the discharge side, which includes the ejector. Residual water in the crock may be siphoned out to complete the cleaning job.

DESCRIPTION AND OPERATION OF SMALL PUMP

Figure 4, a photograph of the small equipment, and Figures 5 and 6 show details of construction and assembly. The pump and motor were purchased as a unit, and the frame was constructed from angle iron and strap. Various members of the frame were welded; these included the top bend and plate of the pump support and the joints of all the members supporting the 5 gallon crock. The cylinders holding the swivel casters also were welded into place. The wire screen basket was constructed from stainless steel screen (20 x 20 mesh) supported on a stainless steel rod frame. It was fitted to slide easily in and out of the crock.

The operation of this equipment is somewhat similar to that of the larger assembly. This pump requires priming to start. This is done simply by running water into the crock until it is slightly above the end of the intake tube Then the running water is sent into the 3/8 inch intake tube. The motor is turned on when the water starts coming out of the ejector. The rubber tubing is removed from the inlet tube at the same instant the motor

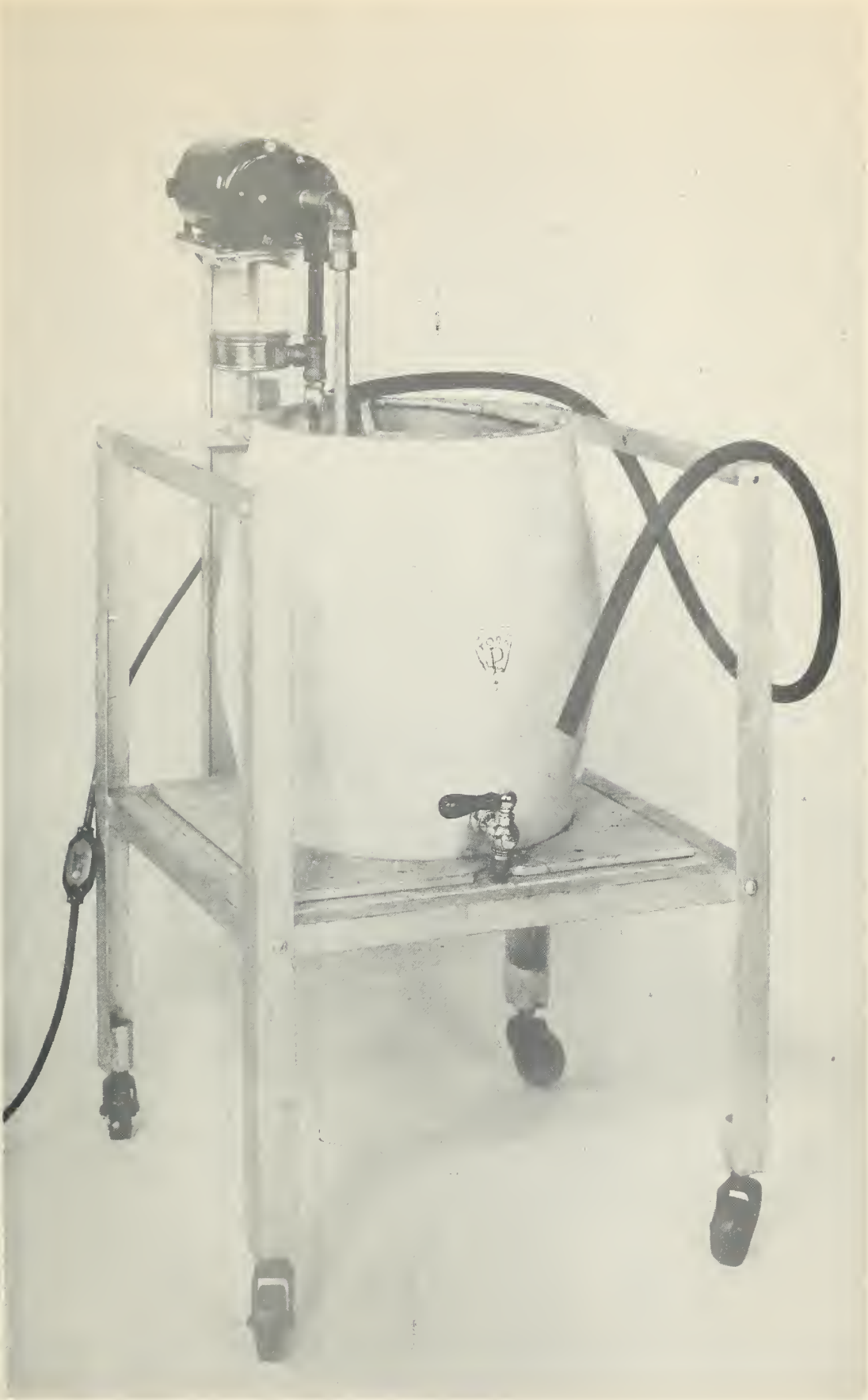


FIG.4

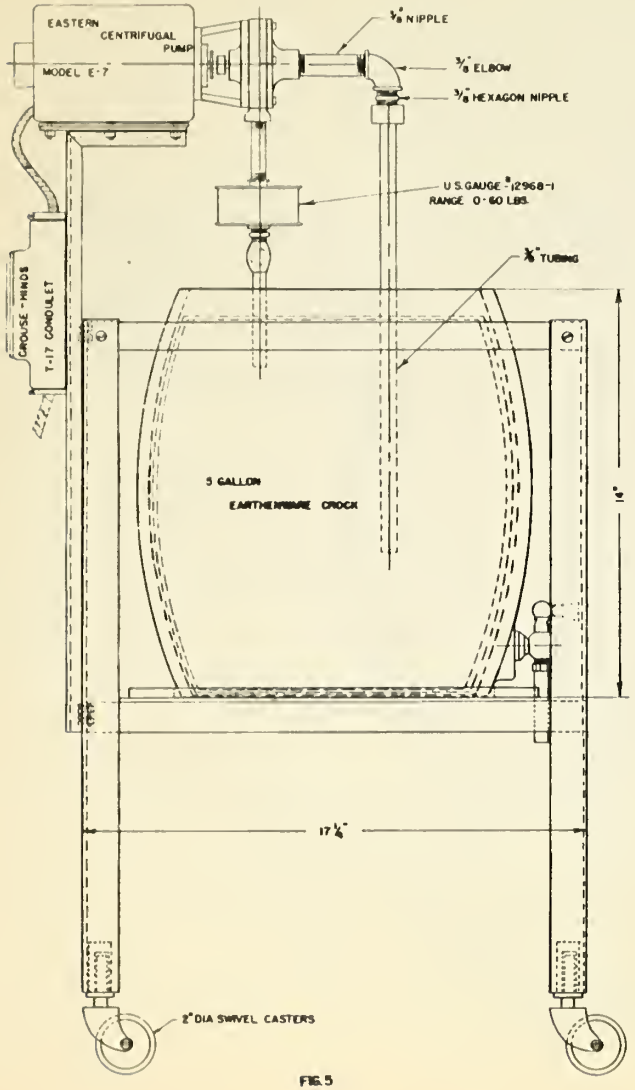

EASTERN CENTRIFUGAL PUMP
MODEL E-7
⅛" NIPPLE
⅛" ELBOW
⅛" HEXAGON NIPPLE
U.S. GAUGE #12968-1
RANGE 0-60 LBS.
⅜" TUBING
CROUSE-HINDS T-17 CONDULET
5 GALLON EARTHENWARE CROCK
14"
17¼"
2" DIA SWIVEL CASTERS

FIG. 5

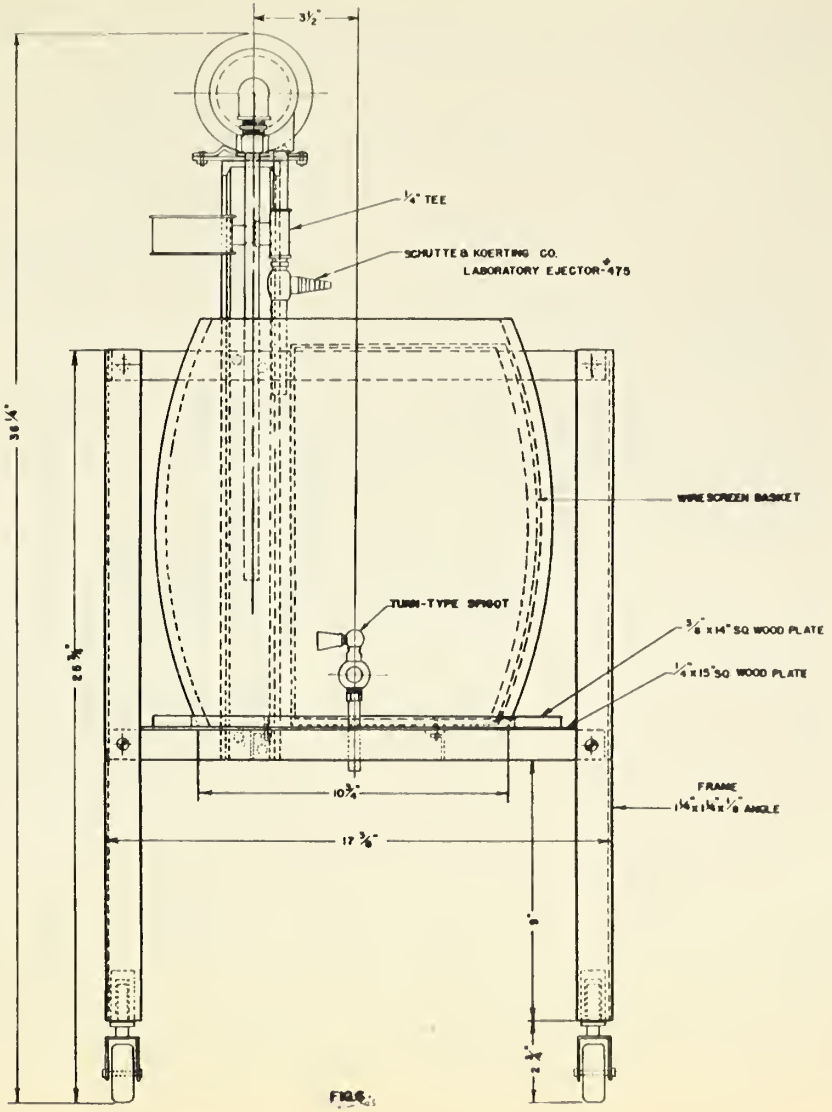

3½"
¼" TEE
SCHUTTE & KOERTING CO.
LABORATORY EJECTOR #475
36¼"
WIRE SCREEN BASKET
TURN-TYPE SPIGOT
⅜" x 14" SQ. WOOD PLATE
¼" x 15" SQ. WOOD PLATE
28¾"
10¾"
FRAME
1¼" x 1¼" x ⅛" ANGLE
17⅜"
9"
2¼"

FIG. 6

is turned on. This operation may require a little practice. An alternative method of priming this type of pump requires a slight modification of structure. A Tee is inserted between the pump and inlet tube. The third opening of the Tee is connected to a gate valve and 3/8 inch brass soldering nipple. Water is run in through the nipple and open gate valve, and the motor is started. The gate valve is closed when the pump is primed.

When the apparatus is operated, the water level in the crock should be about 1 inch above the end of the ejector. If a good vacuum is required, the wire basket should be filled with clean ice to keep the temperature of the water low. The small ejectors are sensitive to dirt and small particles. The wire basket acts as a large filter for the intake line. Because of the high speed motor and pump (6000 R P M.) and relatively small diameter intake tube, a small filter on the intake line retards the flow so much that the apparatus does not work properly.

The assembly operates normally at a water pressure between 30 and 34 lbs. per square inch, and supplies adequate water at this pressure to operate a good laboratory ejector.

Water may be drained by means of a turn-type spigot to make room for more ice as needed, or to empty the crock when a run is completed. The pump and ejector are washed by the method described for priming the pump.

A solenoid valve, trap and check valve may be attached to this assembly just as described for the larger equipment. If neither solenoid nor check valve is used, as shown in Figures 5 and 6, the motor should not be turned off until after the vacuum connecting line from the ejector to the system being evacuated has been clamped or disconnected.

Inasmuch as this smaller apparatus does not have the pumping capacity of the large one, a good vacuum is achieved only in well-assembled systems having tight joints.

ACKNOWLEDGMENTS

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LITERATURE CITED

1. C. TOURNEUX. *Bull. Soc. Chem.*, **41**: 901-4 (1927).

2. ROBERT C. HOCKETT. *Ind. Eng. Chem., Anal. Ed.*, **12**: 539 (1940).

3. S. T. BAUER. *Oil and Soap*, **23**: 2 (1946).

4. F. W. BREUER. *private communication*. ARMSTRONG CORK CO., LANCASTER, PA.

5. H. M. SULLIVAN. *Rev. Sci. Instruments*, **19**: 1 (1948).